# Chapter 5 Alaska—At Risk

*To find a diet free from DDT and related chemicals, it seems one must go to a remote and primitive land, still lacking in the amenities of civilization. Such a land appears to exist, at least marginally, on the far Arctic shores of Alaska—although even there one may see the approaching shadow. (Rachel Carson, 1962)*

Risks posed by persistent organic pollutants (POPs) to Arctic ecosystems and human populations were central to the genesis of the Stockholm Convention, and remain a primary concern when evaluating potential POPs impacts. For the United States, "Arctic ecosystems" means Alaska. Once, not too long ago and within the living memory of Native Alaskans, the Arctic was a pristine wilderness where POPs were never used and could not be detected in wildlife or humans. But the face of Alaska is changing, with increasing urbanization, industrialization, extractive resource activity, and commercial and social contacts with the global community. Accompanying these changes are concerns that the physical, climatic, and social aspects that make Alaska special—particularly for the indigenous population—also make this region peculiarly prone to risks from global pollutants. Although POPs risks are being noted at this time, their impact will be more evident in the future unless pollution issues are addressed now.

As the data to follow demonstrate, Alaska's wildlife and humans are experiencing POPs contamination from local, regional, and international sources. The levels in most environmental media typically remain substantially below those found in highly polluted areas of the lower 48 United States, but in high-trophic-level feeding species—including killer whales and humans—some POPs levels have been recorded that are comparable to those found in the general United States population and similar marine mammal species. POPs contamination of the Great Lakes started as a predominantly regional and local phenomenon, and the initial management successes from domestic and binational strategies with Canada reflected this scale. For Alaska, however, the intervention options mandate a much more global approach. From a polar perspective, "close" to Alaska and its surrounding waters means the huge and growing industrial and population centers in Asia, less regulated neighbors just a few miles distant in Russia, and sources across the Arctic Ocean in Europe that are all closer than Washington, DC (Figure 5-1).


*Figure 5-1. Map of Alaska. Major roads in red.*
With permission of the National Geographic Society

This review of POPs in Alaska intentionally links assessment of human health with the state of the environment and ecosystems. For Alaska Natives, there is a deep connection among the air, the water, the animals, and humans. When people perceive that they are one with the environment, and the environment is contaminated, then they also are contaminated. This integrated world view differs from traditional "Western" practice, which has, in the past, tended to separate humanity from its supporting ecosystems. The many similarities in POPs toxicities between humans and other mammalian species suggest that it would be unwise to hold to the belief that humanity is somehow impervious to and distinct from impacts on the supporting ecosystems.

### *Why Is Alaska at Special Risk?*

For a variety of reasons, Alaska ends up as an ultimate receptor and "sink" for POPs. The persistence and potential effects of these deposited POPs may also be more pronounced in polar climates. Factors in evaluating POPs risks to Alaska include:

- *Location:* The large expanse of the State of Alaska, accentuated by its island chains (Aleutians, Pribilofs), means that its neighbors are not limited to the great ocean expanses or to Canada and Mexico/Caribbean, as is the situation for the other United States. In addition to Canada, Alaska's neighbors are Russia, Japan, China, Korea, and other upwind Asian countries. Russia is the nearest trans-Pacific neighbor, only a short kayak excursion away, and human and wildlife populations regularly traverse these artificial national boundaries.

- *Physical climate:* Needless to say, winter is cold in Alaska, but spring and summer are times of relative warmth (Figure 5-2) and rapid biological activity. The cycle of prolonged winter darkness and cold, followed by warmth and 24-hour light, places peculiar stresses on ecosystems. Through the winter, mammals rely on fat stores, thereby releasing lipid-soluble POPs within their bodies as the fat is metabolized. In the spring melt, POPs that have accumulated in the ice are released to the food chain during the limited time of peak productive and reproductive activity. And, throughout all of this, the predominantly cold temperatures and permafrost reduce or eliminate the microbial activity necessary to degrade POPs.

- *Ecological sensitivity:* Cold temperatures and long periods of darkness are associated in the Arctic with slow growth, low productivity, and low diversity in terrestrial ecosystems. Anthropogenic damage to such ecosystems can require a long period for recovery.

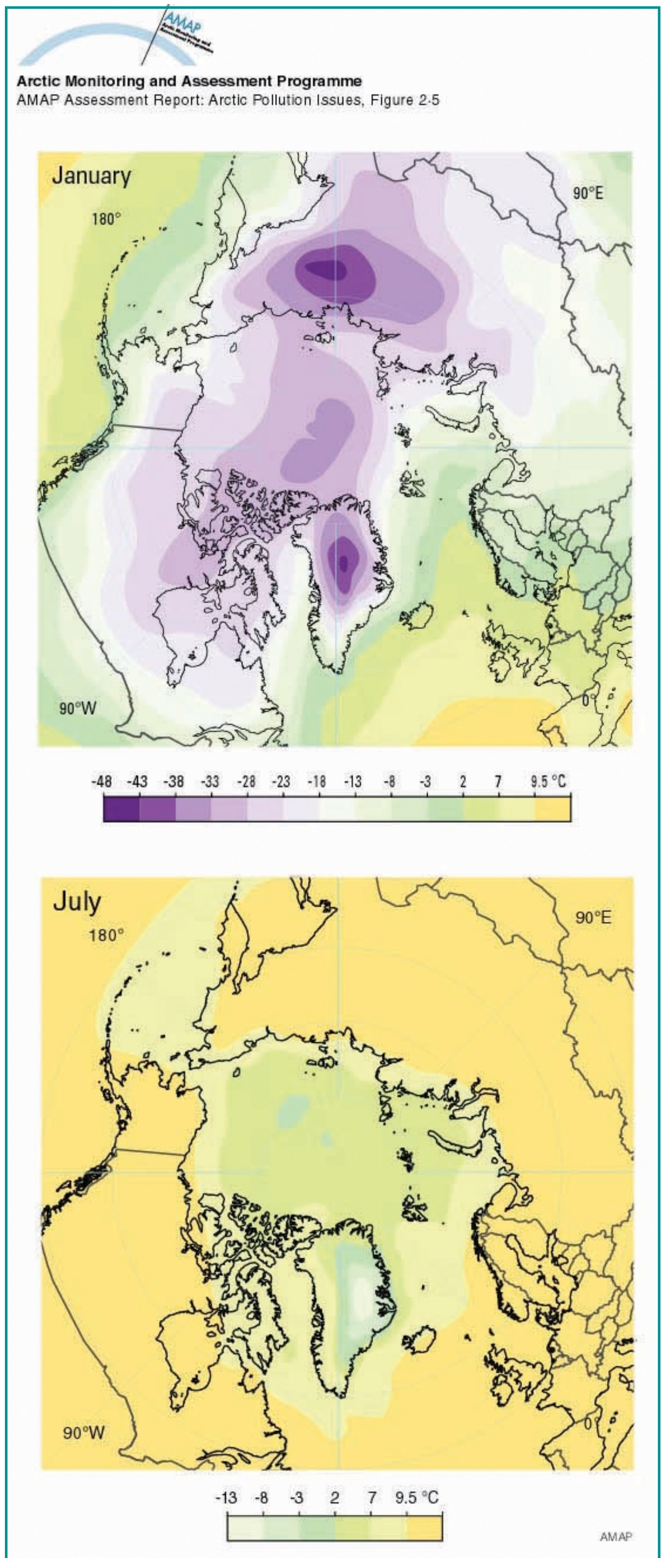



*Figure 5-2. Arctic temperature profiles: January and July. AMAP.*

- *Fat as the currency of life:* Survival for all species in polar climates rests on securing and maintaining energy levels. Some animals have a round body design with thick layers of insulating fat (e.g., fish, seals, walrus, and whales). Another strategy is to secure a regular supply of high-energy food, as used by sea otters and weasels. Fat is high-energy food. Polar bears eat seals by killing them and then stripping off and consuming the skin and fat. Likewise, brown and black bears catch salmon and strip off the skin and fat, which are consumed. Fat becomes the currency for survival in the Arctic. Each predator targets the consumption of fat to maximize energy transfer. In this process, lipophilic contaminants are passed efficiently up the food chain and, at each trophic level, are biomagnified, accentuated by both their persistence and volume of consumption. This economy includes humans near the top of the web, as is evident in the fat rich diet of Alaska Natives.

- *Human populations:* A large proportion of Alaskans are indigenous peoples—16% by the 2000 Census. In the more isolated regions of the State, Alaska Natives make up nearly all of many community populations (Figure 5-3). The indigenous population has a greater proportion of children and elderly than the overall Alaskan population, a result of in- and outmigration by working age, nonindigenous persons. Obtaining wild food is central to the cultural, religious, and economic identity and survival of these peoples. Through traditional fishing, hunting, gathering, and food processing, known as subsistence, the culture and society of native indigenous populations are maintained. Because of concerns about contamination in locally obtained foods, people turn to the purchase of imported foods. This is an economically untenable position in remote Alaskan villages, as well as unfortunate because foods purchased at stores also contain POPs (Schecter et al., 1997; Schecter and Li, 1997). Subsistence hunting and fishing by humans at the top of the food chain also relies on high fat intake, including the consumption of other predators, which can compound the biomagnification of POPs. Thus, the reliance of Alaska's people on wild and traditionally obtained local foods is more pronounced than in any other region of the country, and contributes to Alaskans' concerns regarding international sources of pollution (Hild, 1995).

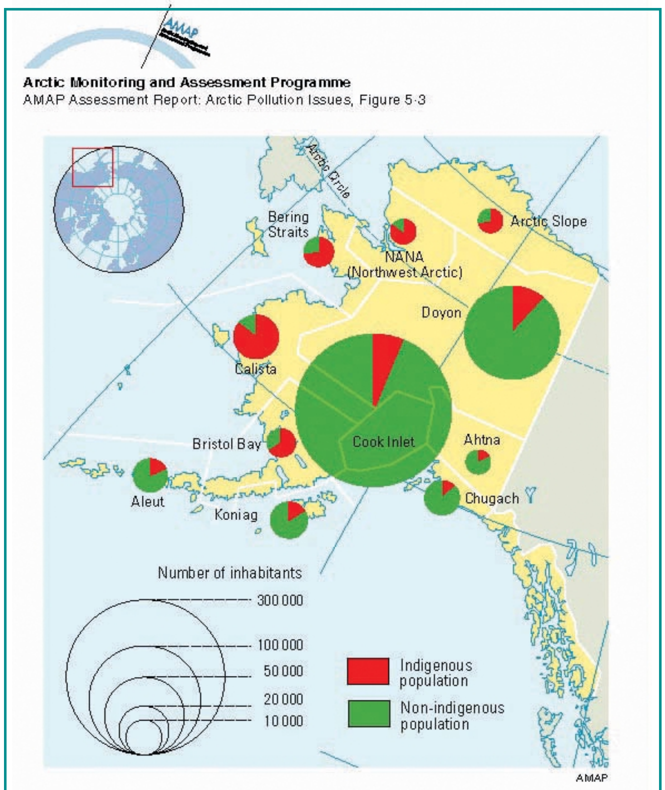



*Figure 5-3. Total and indigenous populations of Arctic Alaska. AMAP.*

- *Previous absence of contamination:* Compounding Alaska's susceptibility is the recognition that its remote areas were previously uncontaminated, with little to no local use of POPs pesticides and industrial pollutants except around urban settlements and military bases (Durham et al., 1961; Hayes et al., 1958). Any contamination comes in stark contrast to the expected purity, even if Alaskan levels remain below those in the lower 48 States. There is significant economic value in safeguarding this food supply, and likely more so in the future. This is particularly significant for a region such as Alaska where primary production (e.g., seafood) exports to the rest of the Nation and the world are central to economic prosperity.

## POPs Transport to Alaska

POPs are transported through the environment to Alaska through the movement of air, water, and migratory species (e.g., fish, birds). These processes are anticipated under the Stockholm Convention and elaborated upon in Chapter 7 of this report. Many physical aspects of the circumpolar region now appear to contribute to a natural transboundary movement of POPs to Alaska. Review of these pathways in the context of a global treaty must not, however, be interpreted as overlooking the contribution of other regional or local sources. Although Alaska has not had industrial POPs manufacturers, there are incidents of past usage that include military sites (e.g., PCBs) and mosquito control efforts (e.g., DDT). Some local waste burning may contribute byproducts (e.g., polychlorinated dioxins and furans). These are under further domestic and local investigation, and source reduction strategies are taking place.

## Atmospheric Transport

Atmospheric air patterns move pollution from around the Northern Hemisphere into the Arctic (Figure 5-4) (Crane and Galasso, 1999). Winds blow in the midlatitudes from west to east, bringing Asian air into southern and central Alaska. During Russian and Chinese nuclear testing in the 1960s and 70s, Alaskans were concerned because they were a short distance downwind. At the same time, in the high latitudes of northern Alaska, wind blows from the east to the west, bringing pollution from northern and western Europe.

As detailed in Chapter 7, air movement can lead to POPs transport and deposition in two basic ways: global distillation of semivolatile chemicals, and mass transport and deposition of POPs attached to dust and soot. For global distillation, a number of the POPs are considered "semivolatile," evaporating in warmer climates, moving north (or south) and then precipitating out in colder climates. This cycle can repeat itself, moving materials poleward in a process known as the "grasshopper" effect (or global fractionation and cold condensation) (AMAP, 1998; Mackay and Wania, 1995; Wania and Mackay, 1993). In addition, all POPs can move to the Arctic through episodic events that move dust particles long distances. As demonstrated through back-trajectory mapping and satellite imagery (Chapter 7), Alaska is downwind of many Asian and European sources.

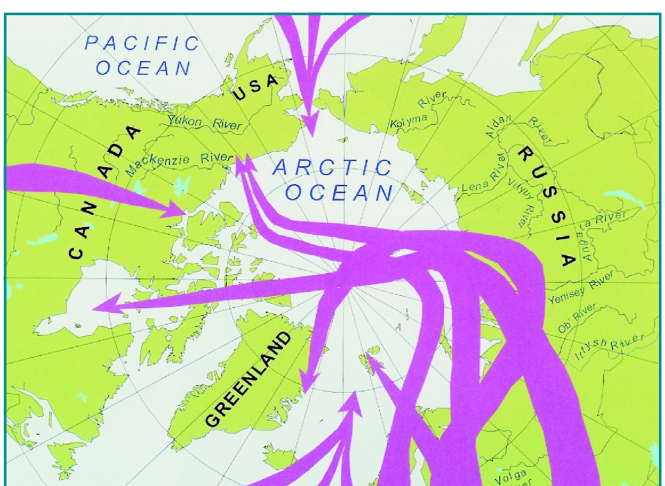


*Figure 5-4. Atmospheric transport pathways to the Arctic (Crane and Galasso, 1999, map 3).*

The atmospheric peculiarities of the Arctic, and the impact of global pollution, are most evident through the phenomenon of Arctic haze. Arctic haze is predominantly attributed to the movement of sulfur oxides and other particles north from their industrial sources. In the 1970s, Matthew Bean, an Alaska Native Yupik elder from Bethel, recognized that the plants were not as green, the sky not as blue, and the horizon not as clear as when he was a boy. He soon found himself talking with academic researchers who corroborated his observations with their air quality measurements. Arctic haze did exist (Kahn and Lowenthal, 1984; Shaw et al., 1993). Further research determined that this haze not only contained pollution from the far north, but contaminants from all over the northern half of the globe. The haze that is made up of these materials becomes increasingly dense during the cold, dark winter. In the spring, the higher angle of the sun warms the air, deepening the mixing layer and depositing pollutants on the earth's surface. The return of the sun also initiates a number of biological activities and unique photochemical phenomena (Lindberg et al., in press) leading to the "Arctic sunrise" effect. The deposition, availability, and metabolic uptake of global contaminants into Alaska's plants, animals, and people generally coincides with the commencement of spring biological activity.

### Hydrologic Transport

The very low water solubility of most POPs—counterbalancing their high lipid solubility—leads to water transport predominantly attached to fine particles. However, some organic pollutants, such as the hexachlorocyclohexanes (e.g., lindane) exhibit higher water solubility leading to transport through a combination of prolonged persistence in cold waters and large volumes of oceanic water movement.

For Alaska, a combination of riverine and oceanic transport can bring POPs from long distances. The major rivers draining the agricultural and industrial areas of Russia flow into the Arctic Ocean. A number of Russian rivers are known to have readily detectable levels of various pesticides, including DDT, that do not appear to be decreasing over time (Zhulidov et al., 1998). A strong current runs from west to east along the coast of Siberia and into the Chukchi Sea, then moves north (Crane and Galasso, 1999). Organochlorine compounds from known PCB and DDT sources in Russia are transported by this current to the Chukchi Sea. There are marine mammal species that feed in the Chukchi Sea and range into Alaska's coastal waters, where they may be harvested for food by Alaska Natives.

Oceanic currents in the Pacific also provide a transport pathway for contaminants (Figure 5-5). After contaminants have traveled down rivers and into the ocean from agricultural fields and industrial areas of Southeast and Central Asia, the western Pacific currents can carry these contaminants to other parts of the world. The currents move along Japan, Korea, and Russia, and finally flow through the Bering Sea and into the Arctic Ocean (AMAP, 1998). Surface water studies of PCBs have identified this movement and the accumulation of materials within the Bering Sea (Yao et al., 2001). Work from Japan on the "Squid Watch Program" is tracking the movements of POPs in the North Pacific driven by the prevailing west wind and the Kuroshio warm current (Shibata, 2001).

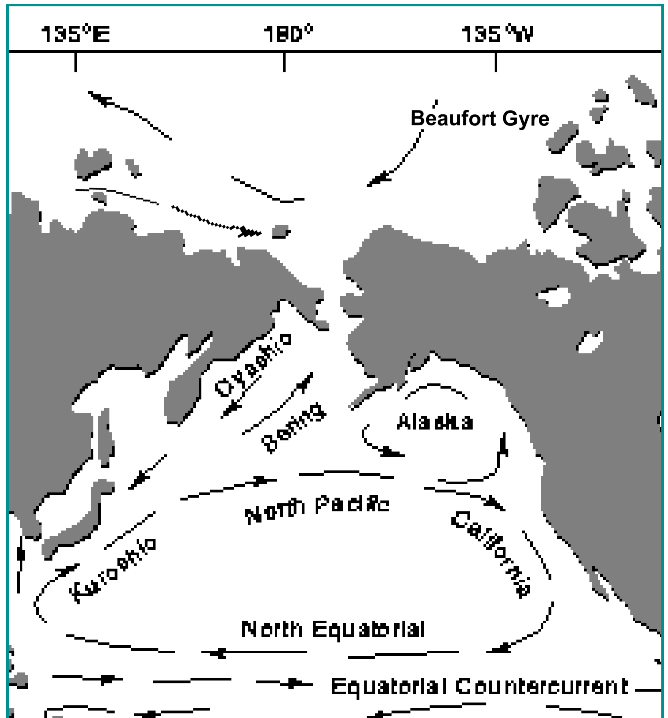



*Figure 5-5. Ocean currents impacting Alaska.*

Source: Adapted from Apel, 1987; NOAA.

### Migratory Species

Transport of contaminants from other regions of the globe to the food supply of Alaska Natives and other Americans can also occur through the movement and harvesting of migratory species. The springtime return of waterfowl is the first fresh meat many Alaska Natives have after a long winter of eating dried meat and stored foods. In addition to adult birds, eggs are also collected and consumed. Some of these birds have wintered in Asia and Central America. In those regions, feeding areas (such as fallow fields) may have been sprayed with organochlorine herbicides and insecticides. The bodies of birds can carry pollutants that may be banned in the American communities that consume them (Crane and Galasso, 1999) (Figure 5-6).

Migratory fish do not travel as far as migratory birds, but the mechanism for accumulation of contaminants is similar. Recently, it was shown that the very low level of certain chemicals detected in sockeye (red) salmon returning to interior Alaskan lakes is greater than levels from atmospheric deposition of HCB, DDT, DDE, DDD, and a number of


*Figure 5-6. Migration routes of land, lake, and wetland birds (Crane and Galasso, 1999, Map #9).*

PCB congeners (Ewald et al., 1998). No studies to date have assessed the sources of chemicals that might be found in low levels in fish species such as salmon, capelin, and pollock that range in the Bering Sea between the United States and Russia. These commercial fish species end up on tables throughout the world, and all have come from an international ocean that receives water from the Western Pacific and Asia (Crane and Galasso, 1999) (Figure 5-7).

Further up the food chain, migratory marine mammals cover large areas, consuming a variety of food sources. These sources in turn lead to different levels of POPs biomagnification. Most seals, sea lions, toothed whales, and polar bears are near the top of the food chain and move among international waters (Crane and Galasso, 1999). Animal species feeding lower on the food chain generally have corresponding lower levels of POPs overall, as well as different specific chemicals. Walrus and bearded seals feed on benthic populations and therefore have a different POPs profile than predators that feed on fish or other marine mammals. Ringed seals eat crustaceans and fish. Likewise, filter-feeding whales, such as bowhead whales, feed low on the food chain, eating krill, and have a very different POPs profile and lower levels overall than the upper trophic level feeders.

## POPs Levels in Alaska

Insights into levels and potential risks from POPs in Alaska are best gained through comparing exposure data to either effect levels in species of concern or to levels found in the lower 48 States. Although zero levels would be the preferred value for all of the POPs, it must be recognized that with the global distribution of these pollutants, their persistence, and modern laboratory equipment, scientists will invariably be able to detect some level


*Figure 5-7. Migration routes of salmon (Crane and Galasso, 1999, Map #13).*

of pollutant, especially in species higher on the food chain. This complexity is compounded by the multiple environmental media and species in which measurements are taken, and the multiple POPs and their metabolites under consideration.

Measurement numbers in isolation are also prone to misinterpretation or exaggeration through such simple changes as unit conversions or moving from whole-body to lipid-adjusted levels. Numbers also must be put into context. That is, the time, the area, the ecosystem, and other biological factors must be considered when assessing any effects. Care must be taken in comparisons of different studies because units of measurement, analytic protocols, and methods of reports may vary. For this report, we compare levels found in Alaska to those in the lower 48 States and, where possible, to the effect levels found in these or similar species from other areas of the Nation. Reflecting the integrated nature of the Alaskan situation, the species discussion commences with wildlife, proceeds through wildlife that are used as food, and concludes with human consumers. For those seeking additional details on species levels across the Arctic, excellent references are available in AMAP (1998), Canadian Northern Contaminants Program (Jensen et al., 1997), Landers and Cristie (1995) and Ritter et al. (1995).

## *Wildlife Levels*

### Bald Eagle

*Bald eagle.*
Photo: U.S. Fish and Wildlife Service

The decline of bald eagle populations to the verge of extinction in the lower 48 States is emblematic of the effect of POPs, DDT/DDE in particular. Although residual DDE contamination continues to affect reproductive rates in some areas, the recovery of bald eagle populations in the lower 48 States following the cessation of DDT use has been a remarkable success. In Alaska, bald eagle populations have remained robust, with DDT/DDE levels

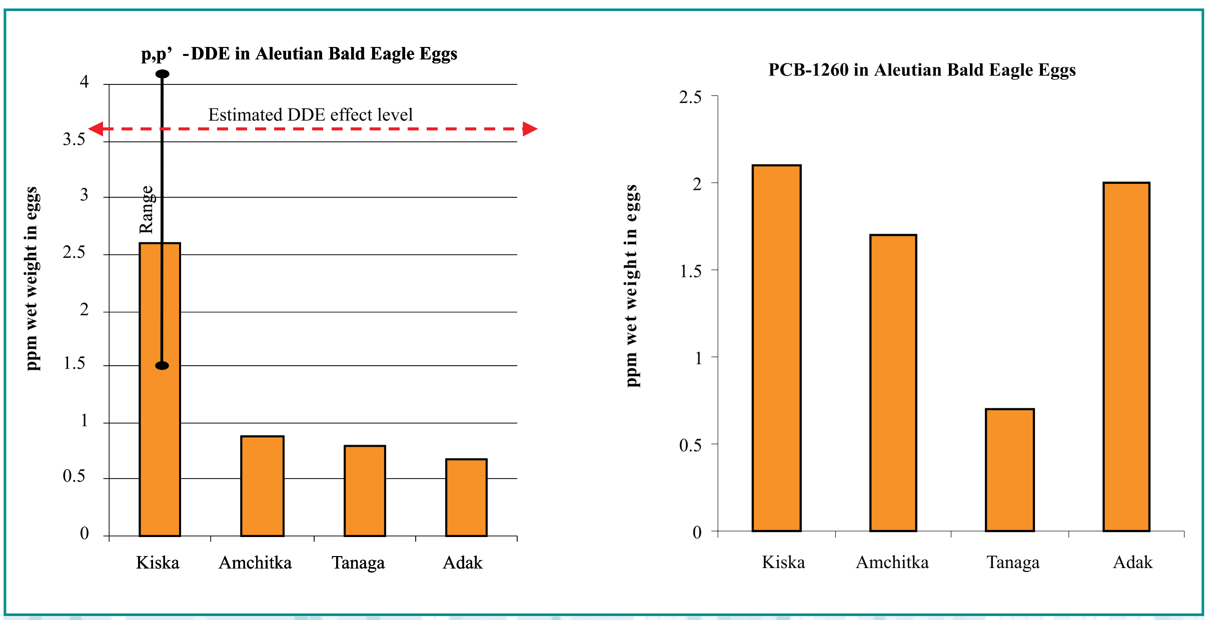



*Figure 5-8a,b. Bald eagle levels of DDT and PCBs in the Aleutians (Anthony et al., 1999).*

generally well below the potential effect level of ~3.6 µg/g DDE (Anthony et al., 1999; Wiemeyer et al., 1993). Eagles nesting along the Tanana River in the interior of Alaska in 1990-91 had DDE levels below concentrations known to result in sublethal or lethal effects, and most organochlorine concentrations were an order of magnitude lower than concentrations in bald eagle eggs from elsewhere in the United States (Richie and Ambrose, 1996). However, even in the presence of this apparent success there are warning signs. Eagles in the western Aleutian Islands have been found to have ratios of DDT/DDE that indicate new DDT sources, and DDE levels in some eggs on one island (Kiska) may be depressing reproductive success (Anthony et al., 1999; Estes et al., 1997) (Figure 5-8). Although the sources are not yet known, the prey species, especially migratory birds from Asia where DDT is still used, need to be assessed further. It also should be noted that although DDE is suspected as the causative agent in the above-mentioned studies, DDE concentrations in eagle eggs were positively correlated with other organochlorines, including oxychlordane, beta-HCH, dieldrin, and hexachlorobenzene.

## Peregrine Falcon

*Peregrine falcon.*
Photo: U.S. Fish and Wildlife Service

Historic declines in peregrine falcon populations at several locations, including Alaska, have been correlated with DDE concentrations in their eggs causing eggshell thinning and hatching failure. Peregrine falcons in interior and northern Alaska declined during the 1960s, stabilized in the mid-1970s, began to increase in the late 1970s, and have since stabilized or continued to increase. Eggs from two subspecies of peregrine falcons were collected from interior and northern Alaska between 1979 and 1995 and analyzed for organochlorine compounds and metals, including mercury (Ambrose et al., 2000) (Figure 5-9). This study represents one of the few relatively long-term data sets from Alaskan biota and can offer some insight into POPs residue trends with time. In general, organochlorines declined over time, although the trend was not as strong for PCBs, which declined

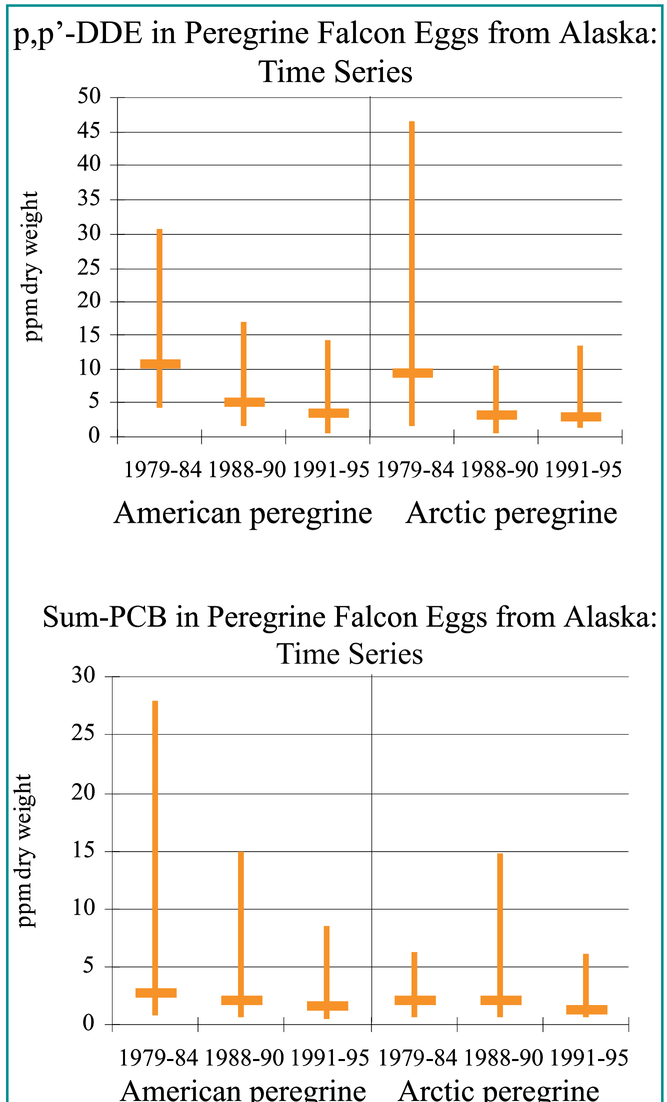



*Figure 5-9a,b. Time trends for DDE and PCBs in Alaskan peregrine falcon eggs (Ambrose et al., 2000). Geometric mean and range.*

more slowly. These results agree with trends observed in other peregrine falcon populations, which show that PCB concentrations have not decreased as clearly as other organochlorine compounds (Peakall et al., 1990; Newton et al., 1989; Johnstone et al., 1996). Although organochlorine levels have decreased over time, evidence for cumulative and single-contaminant reproductive effects was found in remote locations. Contaminant monitoring remains a necessary management tool for this species, which is recovering from near extinction caused largely by environmental contaminants, and continues to remain vulnerable to persistent and bioaccumulative compounds.

## Killer Whale

*Killer whales spy-hopping.*
Photo: Craig Matkin

Certain populations of killer whales (*Orcinus orca*) have been extensively studied over the past 30 years, including populations in Puget Sound, Washington, the inside waters of British Columbia, Southeastern Alaska, and Kenai Fjords/Prince William Sound, Alaska. The POPs concentrations found in some populations of Alaskan killer whales were similar to those recently reported in pinnipeds and cetaceans that occur in more contaminated waters (Ylitalo et al., in press). Levels of total PCBs in blubber ranged up to 500 ppm, and total DDTs ranged up to 860 ppm, while median levels and some group levels were significantly lower (Figure 5-10). Concentrations of POPs in transient killer whale populations (marine mammal-eating) were much higher than those found in resident animals (fish-eating) apparently because of differences in diets (amounts and types of fat consumed) and feeding locations (localized or broad-ranging) (Ylitalo et al., in press). Both resident and transient whale groups described in the report reside in Alaskan waters, although they may move hundreds of miles up and down the coast through international waters.

Life-history parameters such as sex, age, and reproductive status also influence the concentrations of POPs in Alaskan killer whales. Reproductive female whales contain much lower levels of POPs

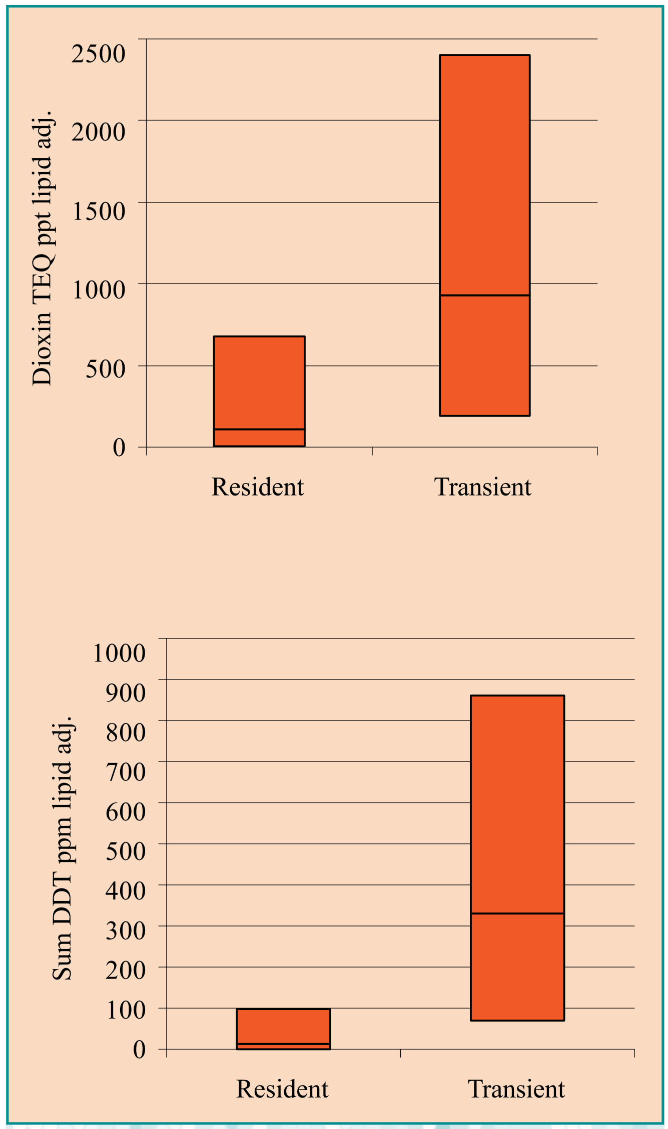



*Figure 5-10. Dioxin TEQ and Sum-DDT in Alaskan resident v. transient killer whales (Ylitalo et al., in press). Mean denoted by horizontal line, range as vertical bar.*

than sexually immature whales or mature male animals in the same age class. This is likely due to transfer of POPs from the female to her offspring during gestation and lactation. Birth order also influences the concentrations of POPs. Adult male, resident, first-born whales contain much higher OC concentrations than are measured in subsequent offspring to resident animals in the same age group (Ylitalo et al., in press). There is also some evidence of decreased survival of the firstborn transients that have the highest POPs levels (Matkin et al., 1998, 1999).

Reports of POPs levels in killer whales have been associated with decreases in reproductive success (Matkin et al., 1998, 1999). The causal factors for low reproduction and population decline of certain transient groups of killer whales from Prince William Sound/Kenai Fjords are not known. The low reproduction and population decline may be a natural cycle, related to human factors (e.g., oil spill), exposure to natural toxins (e.g., biotoxins), decline in the primary prey species (harbor seal), or a combination of environmental and anthropogenic factors. Exposure to toxic POPs may also be a contributing factor (Ylitalo et al., in press).

## Sea Otter

*Sea otters.*

Photo: Craig Matkin

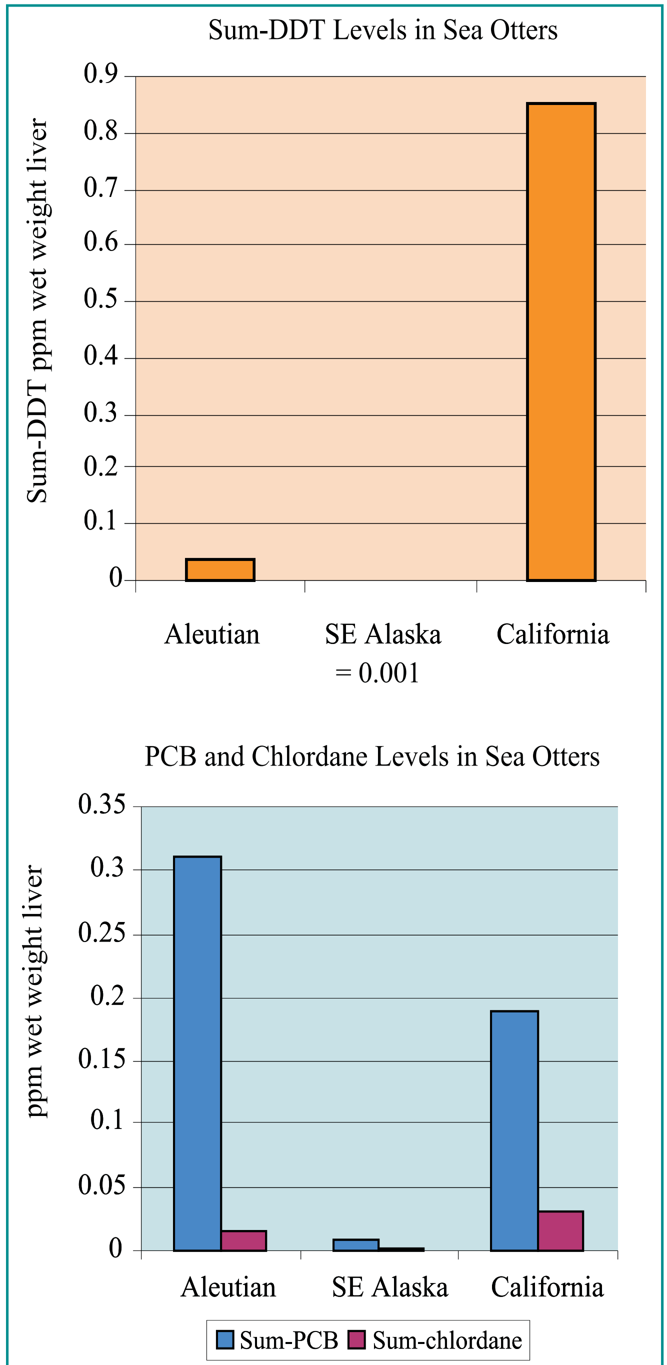



*Figure 5-11a,b. Comparison of POPs levels in Aleutian, Southeastern Alaskan, and California sea otters (Bacon et al., 1999). Mean values.*

Sea otters have declined precipitously throughout the Aleutian Islands over the past decade. Although investigations to date suggest predation may be the primary cause of the decline, contributing factors such as contaminants have not been completely ruled out. Sea otters at several isolated sites in the Aleutians (Adak, Shemya) have been recorded with elevated levels of certain POPs, particularly PCBs (Giger and Trust, 1997). PCB levels in sea otters from the Western Aleutian Islands (Adak and Amchitka Islands) were somewhat higher than levels found in California sea otters, and were significantly elevated relative to PCB concentrations in sea otters from southeast Alaska (Bacon et al., 1999) (Figure 5-11). Sum-DDT levels in Aleutian otters, although much higher than the very low values found in Southeast Alaska, remain substantially lower than in California otters. These sum-DDT concentrations were not in the range that causes reproductive impairment in captive mink, a commonly used comparison and related species. However, there is little information that can help evaluate whether there may be interactive effects among POPs and other stressors affecting Aleutian sea otters.

*Beluga whales.*
Photo: NOAA

## *Species Consumed by Humans*

### Beluga

Beluga whales (*Delphinapterus lucas*) are a preferred food for many Alaska Natives. The muktuk (the skin and outer layer of fat) is considered a choice item for consumption. This outer layer of fat contains the highest levels of POPs in the animal (Wade et al., 1997). The blubber of beluga whales from Alaska contains POPs in concentration ranges similar to those found in beluga whales from the Canadian Arctic (Muir and Norstrom, 2000) but much lower than levels in whales from the highly contaminated St. Lawrence River in eastern Canada (Krahn et al., 1999) (Figure 5-12). Within Alaskan stocks, the Cook Inlet stock in

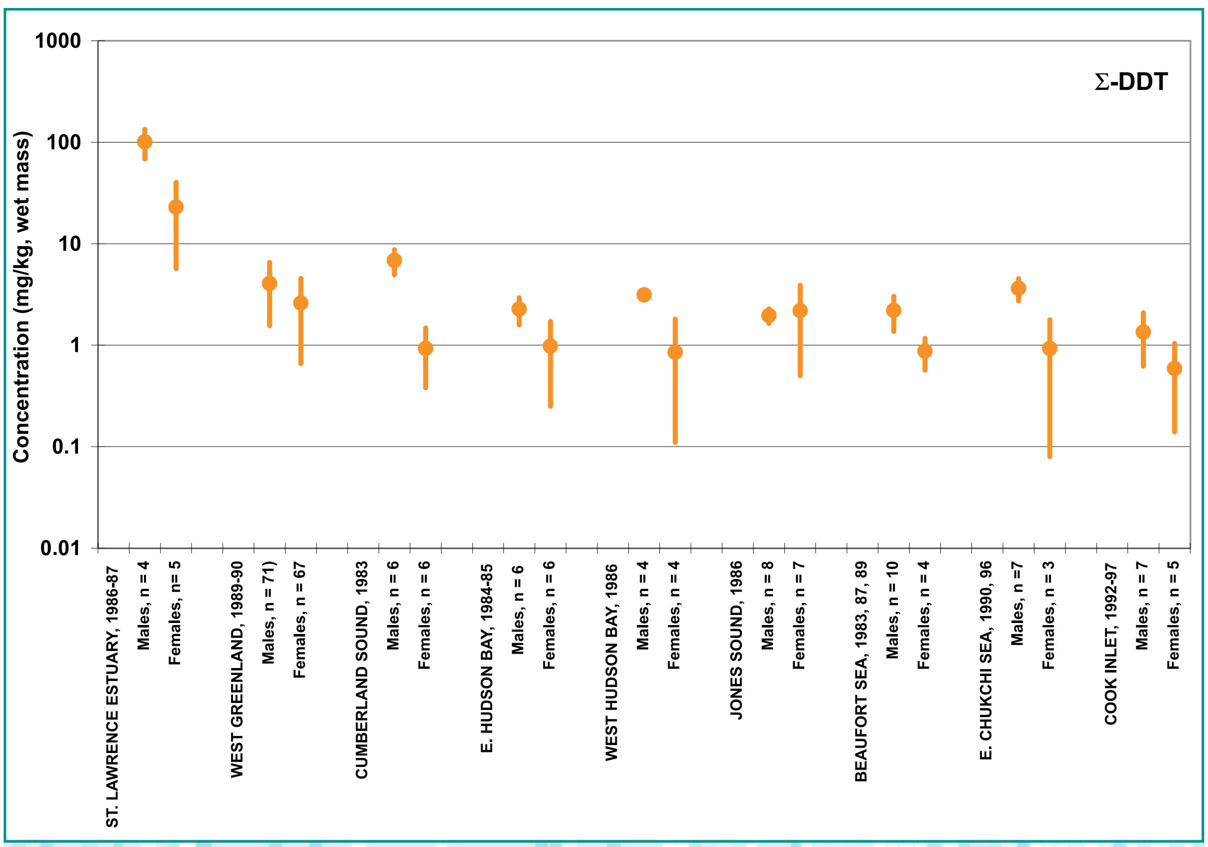



*Figure 5-12. Sum-DDT levels in Beluga blubber, log scaled (Becker et al., 2001).*

south-central Alaska generally has the lowest concentrations of POPs, and the Eastern Beaufort Sea and Chukchi Sea stocks in northern Alaska have the highest concentrations. The lower levels in the Cook Inlet stock occurred even though these animals reside in one of the most "urban" areas of Alaska, where anthropogenic contamination could be expected to result from the relatively higher density of human residents and commercial activities (Krahn et al., 1999).

Gender is an important factor to consider when interpreting differences in POPs concentrations among beluga whale stocks (Krahn et al., 1999). For example, the adult males of each stock had higher mean concentrations of all contaminant groups than did the adult females of the same stock. This is considered to be an effect of POPs transfer from the mother to the calf during gestation and lactation. This theory is supported by the finding that upon reaching sexual maturity, the levels of toxaphene, PCBs, DDTs, and chlordane steadily go down in females as they produce calves and lactate, whereas levels in males continue to go up as they feed and accumulate the chemicals (Wade et al., 1997).

## Bowhead Whale

*Bowhead whales.*

Photo: NOAA

The bowhead whale stock (*Balaena mysticetus*) migrates through the Bering, Beaufort, and Chukchi Seas and is listed as an endangered species. Alaska Natives are the only U.S. citizens permitted to harvest the bowhead whale for food. Studies have shown relatively low levels of PCBs in bowhead whale blubber, but these levels tend to increase with age (McFall et al., 1986; O'Hara et al., 1999) (Figure 5-13). Previous reports support the view that these large filter-feeding whales, consuming at a lower level on the food chain, have lower levels of POPs in their blubber. Toothed whales, eating higher on the food chain, may have one or two orders of magnitude more POPs than the filter-feeding whales (O'Hara and Rice, 1996; O'Shea and Brownell, 1994; Borell, 1993).

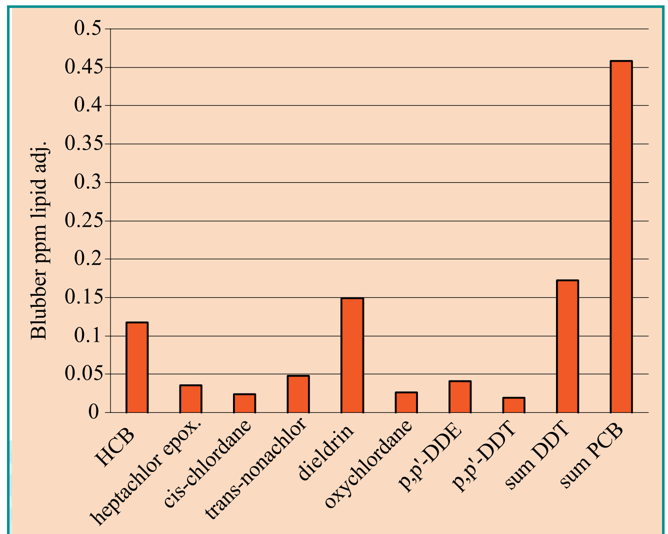



*Figure 5-13. POPs levels in bowhead whale blubber (O'Hara et al., 1999). Mean values.*

## Seals

*Northern fur seals.*

Photos: Suzanne Marcy

The various seal species in Alaska constitute a substantial portion of the marine mammal diet of numerous predator species, including humans. Blubber samples from four Alaskan seal species (bearded seal, *Erignathus barbatus*; harbor seal, *Phoca vitulina*; northern fur seal, *Callorhinus ursinus*; ringed seal, *P. hispida*) have been collected and analyzed for organochlorine (POPs) contaminants (i.e., total PCBs, total DDTs, total chlordanes, HCB, and dieldrin) (Krahn et al., 1997). Harbor seals, frequently consumed by Alaska Natives, were found to have low but measurable levels of several of these POPs (Figure 5-14). The concentrations of POPs in harbor seals from Prince William Sound were generally much lower (e.g., total PCBs up to 100-fold and total DDTs up to 30-fold lower) than those recently reported for harbor seals from other regions, including animals involved in mass mortality events (Krahn et al., 1997) (see details in Chapter 6, Marine Ecosystems). For Alaska, however, the issue is compounded because harbor seals are consumed by humans, an additional one or more trophic levels higher, thereby further biomagnifying the POPs.

Notable among the multiple studies of seal species is the finding that POPs concentrations in male subadult northern fur seals sampled in 1990 at St. Paul Island in the Bering Sea were higher than concentrations in the ringed and bearded seals from the Bering Sea or in the harbor seals from Prince William Sound. Fur seals feed mainly on oceanic species such as squid and pollock. Harbor seals feed on different species of fish that tend to be very coastal, like perch. Female and juvenile fur seals migrate long distances into the open ocean of the northern Pacific far south of Alaska and even to the shores of Japan, as well as California. Harbor seals do not migrate, but stay close to their coastal feeding and haul-out areas.

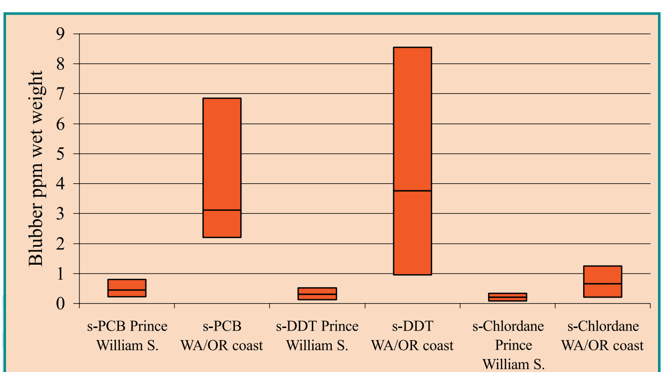



*Figure 5-14. POPs levels in Alaskan v. West Coast U.S. harbor seals (Papa and Becker, 1998).*

## Steller Sea Lion

*Steller sea lions.*

Photo: NOAA

Studies show that PCBs are the predominant POPs in sea lion blubber, followed by levels of DDT/DDE. Levels of chlordane compounds were an order of magnitude lower (Lee et al., 1996). There are two stocks of Steller sea lions in Alaska. The levels of PCBs and DDTs in these animals indicate that the populations have different sources of exposure. The western stock, which includes animals from Prince William Sound and into the Bering Sea, have significantly lower levels than those from the eastern stock, which reside primarily in southeast Alaska and along the coast through Canada and the U.S. Pacific Northwest (Lee et al., 1996). Like the beluga whales, as Steller sea lion females become sexually mature they show a dramatic decline in POPs levels. It has been calculated that they may lose 80% of their PCBs and 79% of DDT/DDE through lactation while nursing the first pup (Lee et al., 1996). Two studies of PCBs in Steller sea lion blubber found an average of 23 ppm (Varanasi et al., 1993) and 12 ppm in males (Lee et al., 1996). These PCB levels in Steller sea lions found by Lee and colleagues prompted human health evaluations in associated human populations (Middaugh et al., 2000a,b; see following).

## Salmon

*Alaskan fisher and sockeye salmon.*

Source: NOAA

Salmon species are key to Alaska's commercial fisheries and to the well-being of many subsistence communities. For the Alaskan fishing industry, salmon is a billion-dollar business. For subsistence communities who catch and consume their own, fish by weight make up about 59% of the total subsistence harvest for Alaska Natives, with salmon being the most important species (AMAP, 1998). In western Alaska, the fish harvest can approach 200 kg (500 lb) per person per year and make up more than 73% of all locally harvested food (Wolfe, 1996). The U.S. Fish and Wildlife Service is currently assessing contaminant levels and evaluating fish health in salmon from selected Alaskan rivers with funds secured for evaluating food species.

The migratory and reproductive patterns of sockeye salmon (*Oncorhynchus nerka*) are known to provide a means of transport for very low levels of chemicals such as PCBs and DDT to waters used by other species of Alaskan freshwater fish, such as grayling (*Thymallus arcticus*) (Ewald et al., 1998). Migrating salmon carry these low but measurable levels of POPs to spawning areas where, after spawning, they die and decay. The POPs then become bioavailable to other local species. The levels of POPs delivered by salmon to Alaskan interior lakes and rivers have been estimated to be slightly above the levels deposited through atmospheric means, although these levels are far below those found in fish from the Great Lakes region (Figure 5-15).

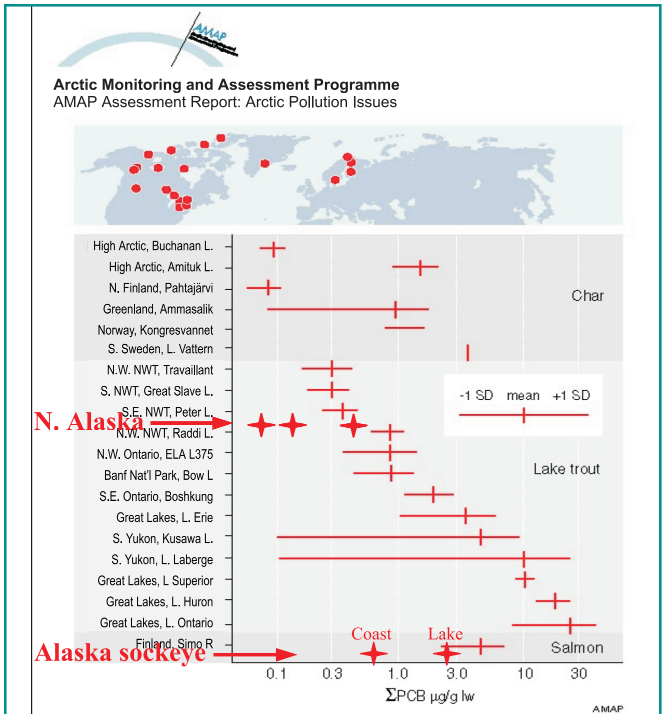



*Figure 5-15. PCB levels in salmonid fish: preliminary Alaskan results overlaid AMAP summary figure (Ewald et al., 1998; Allen-Gil et al., 1997).*

## Polar Bear

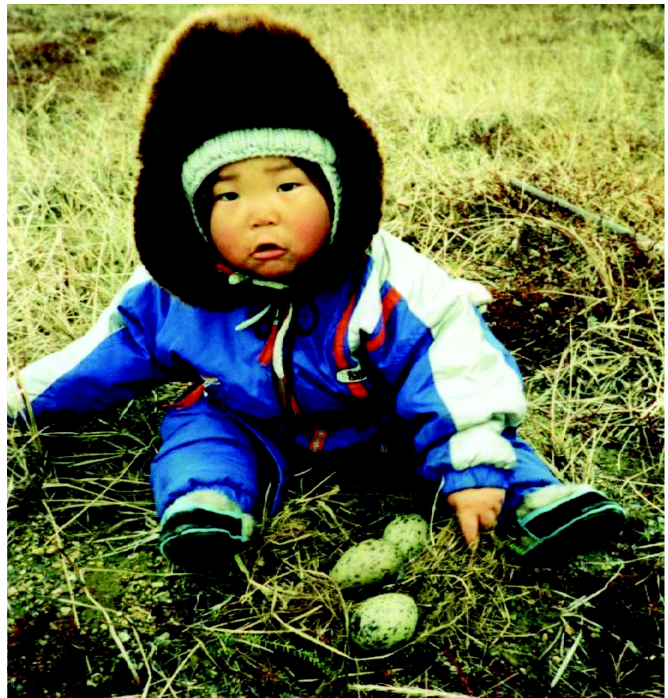
Polar bears are at the top of the Arctic marine food web. Norstrom et al. (1998) investigated chlorinated hydrocarbon compounds in polar bears from much of the circumpolar Arctic. They found strong relationships among contaminant concentrations and sex. Individual dietary preferences, regional differences in species availability, and food-chain structure also contributed to variability within the data. For example, baleen whale and walrus

*Polar bear.*
Photo: U.S. Fish and Wildlife Service

carcasses may be seasonally important food sources for polar bears in the Bering Sea and Chukchi Sea region, supplementing their primary diet of ringed and bearded seals. Walrus (except when eating seals) and baleen whales feed at lower trophic levels than other Arctic marine mammal species. Conversely, polar bears feeding on beluga carcasses in eastern Canada exhibit higher POPs levels. Thus, prey selection can affect the pattern of chlorinated hydrocarbon uptake in these different polar bear populations. Polar bears have therefore been, in part, defined into stocks by their contaminant loads (Lentfer, 1976). Total chlordanes were the most uniformly distributed POPs in this study, reflecting a similar pattern found in air and seawater sampling (Norstrom et al., 1998).

Although sample sizes were small, concentrations of total PCBs, total chlordanes, DDE, and dieldrin in polar bears from the Bering, Chukchi, and western Beaufort Seas tended to be among the lowest in the study area. The atmospheric circulation of this area is dominated by eastward airflow from Asia and the North Pacific Ocean. Sources of organochlorines in the Bering, Chukchi, and western Beaufort Seas are, therefore, more likely to have originated in eastern Asia. PCBs were generally used less often in Asia, except Japan, than in North America and Europe (Norstrom et al., 1998). The U.S. Fish and Wildlife Service Office of Marine Mammal Management continues to work with Alaska Native hunters to collect samples for analysis of environmental contaminants.

## *Native Peoples of Alaska*



*Alaska native child with eggs—a subsistence food.*
Family photo: Jesse Paul Nagaruk

Food is central to culture. Alaska Natives, although sharing different cultural heritages, are linked to their environment through the foods that they gather locally and consume. The social structures that define behavior in the sharing of subsistence harvests and through feasts are the traditions of Alaska Natives—the cultural values of the people. Children and youth are taught about their environment and about their relationship to the community through hunting, fishing, gathering, and sharing. The survival knowledge of the group is passed down from generation to generation, ensuring the transmission of language and values. The work of obtaining one's own food is rigorous and promotes self-reliance and self-esteem. For all of these factors, continued confidence in the quality of locally obtained foods is essential (Egeland et al., 1998).

Alaska Natives eat 6.5 times more fish than other Americans (Nobmann et al., 1992). Under the Marine Mammal Protection Act, Alaska Natives are the only people in the United States allowed to hunt marine mammals, which they then eat. Alaska Natives eat higher on the food chain, consuming predator species (seals, sea lions, bears, and toothed whales) in contrast to the typical American who feeds lower on the food chain, consuming herbivores (cattle, pigs, and chickens). Many Alaskans have wide seasonal variation in their dependence on locally available foods. Their diet shifts in response to short intense summers and the migration of wild birds, fish, and mammals. Alaska Natives eat more fat, albeit different types, than most U.S. citizens (Jensen and Nobmann, 1994; Nobmann et al., 1992; Scott and Heller, 1968). Estimates of the amount and type of subsistence foods consumed by Alaska Natives are summarized in Figure 5-16, documenting levels of dependence and species preferences by area.

In regions where employment opportunities are scarce or seasonal, locally obtained foods remain an economic necessity. Shifting food consumption in remote Alaskan communities is not beneficial for several reasons. Food that is purchased is expensive and rarely fresh owing to the long distances it must be shipped and the number of times it must be handled as it goes into smaller and smaller stores. Many people in these remote communities have very limited food budgets because of the scarcity of jobs and high costs of heating and other costs associated with life in a remote and challenging environment (Egeland et al., 1998).

Store-bought foods in remote Alaskan communities need to have a long shelf life. Therefore, the foods have been frozen, canned, or chemically preserved. Many of these foods do not have the nutritional value of fresh foods from the local area. Marine mammal fats and fish oils differ significantly from pork and beef fats in their ability to provide health benefits. Also, store-bought foods are much higher in processed sugars, saturated fats, sodium, and simple carbohydrates, considered contributors to such conditions as obesity, diabetes, heart disease, and dental caries. These conditions are growing at alarming rates in Alaska (APHA, 1984; Ebbesson et al., 1996; Lanier et al., 2000; Nobmann et al., 1992; Nobmann et al., 1998; Nutting, 1993; Schraer et al., 1996). Health surveys have also indicated that, in some communities, the individuals who are most concerned about environmental pollution are the same people who most frequently consume less traditional foods and are shifting to buying food from the store (Dewailly et al., 1996; Egeland et al., 1998; Hild, 1998).

But, just as Mathew Bean observed the changing colors of the plants and sky, others too have noticed changes in the subsistence species they hunt. These observations, collected now by the Alaska Native Science Commission, may contribute to an understanding of what is occurring in the changing Arctic (*www.nativeknowledge.org*). Over the past few years, Alaska Natives have reported many new

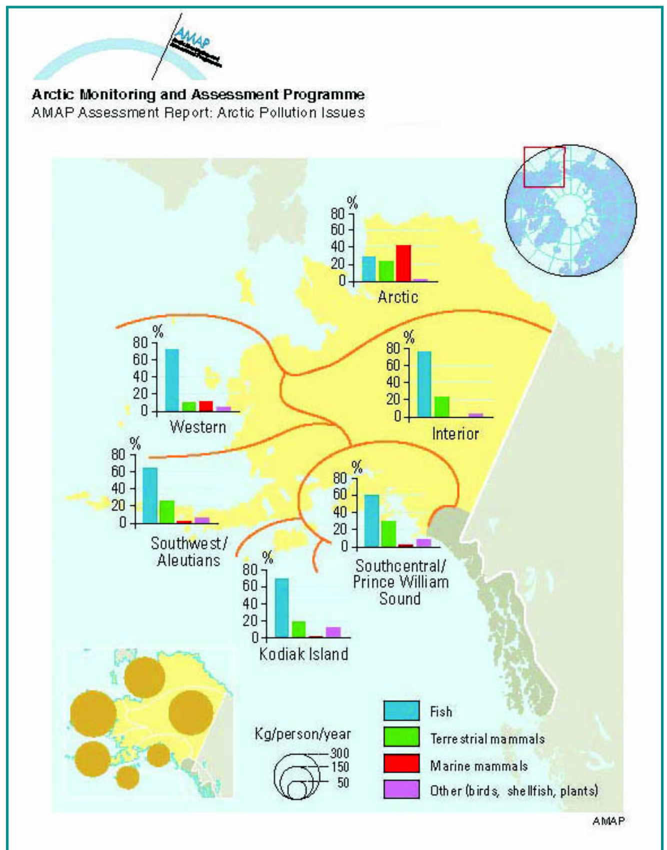



*Figure 5-16. Total and composition of subsistence production in Alaska. AMAP.*

concerns, such as seals with diseases they have not seen before, no hair, yellow fat, fat and meat that does not taste as it should, and seals with abnormal growths and abnormal sex organs. Similar concerns have been raised about other subsistence species.

In the absence of key information to answer specific questions, and in response to media reports about contamination in the Arctic (Figure 5-17), the conclusion being reached by Alaska Natives is that the environment may not be healthy. Therefore, the animals may not be healthy, and the health of their children is at risk. When orcas (killer whales) along the Pacific coast were reported as among the most contaminated marine mammals in the world, there was great concern in Alaska, particularly among Alaska Natives who live near and eat the same foods as the whales (Ross et al., 2000). Recommendations such as "just do not eat the kidneys" in certain species may be acceptable to some people, but for many Alaska Natives a caution about any part of a subsistence species is tantamount to saying the animal is not well. If the kidneys do not look right and are not eaten, then the entire animal is also not well and will not be eaten.

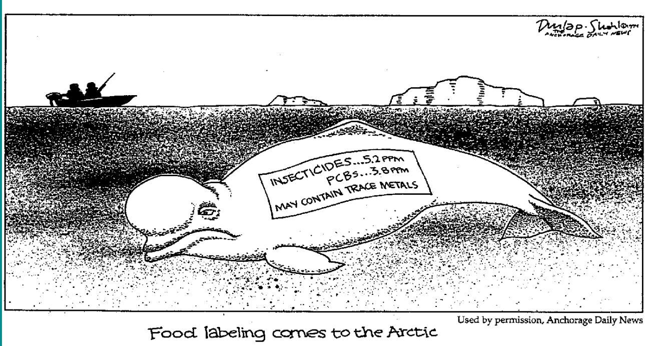



*Figure 5-17. Food labeling comes to the Arctic.*
Cartoon courtesy Anchorage Daily News

## *POPs Levels in Alaska Natives*

Most of the POPs under the Stockholm Convention were never used in or near Alaska. For the other POPs (e.g., PCBs, DDT, polychlorinated dioxins/furans) local use in Alaska and emissions to the environment are much less than has occurred in the lower 48 States. Yet there is considerable concern among residents—particularly Alaska Natives—that they may have become contaminated through consuming traditional foods. The most expeditious way to assess the extent to which Alaskans have been exposed to these persistent toxins is to measure levels in human tissue (Hild, 1995). Unfortunately, there is no statistically based survey of POPs levels in Alaskans. Indeed, there is no national statistically based survey of POPs levels in the U.S. population, although serum has been collected under the NHANES IV study and is being analyzed at the Centers for Disease Control and Prevention (CDC).

POPs levels have been measured in small studies of selected Alaska Native communities, lower-48 background comparison groups, and Great Lakes fishers, providing valuable indicative and comparative information on POPs levels (Figures 5-18 and 5-19). These data highlight that human (and wildlife) exposures to POPs are inherently dependent on what is being eaten and from where it was obtained. As with marine mammal exposures, high trophic level feeding is generally more problematic than lower on the food chain. Thus, Alaska Native diets based on terrestrial plant-eating animals, fish, and plants are, a priori, of less concern than those relying on the consumption of marine mammal predator species. Location and proximity to emission sources and transport pathways must also be considered, as the western Aleutians represent a quite different locale than the Beaufort Sea off northeastern Alaska. Likewise, the subject's age is a major determinant of many POPs levels. As has been evident in lower-48 studies, POPs levels tend to increase with age because of the fundamental persistent and bioaccumulative nature of the toxins, especially in males, where there is no excretion through lactation. Age is also an important consideration for Alaska Native levels, as dietary practices and the proportion of traditional foods in many diets have changed over recent years.

In response to citizen concerns, the State of Alaska, Department of Health and Social Services, conducted a targeted study of POPs in five Aleutian

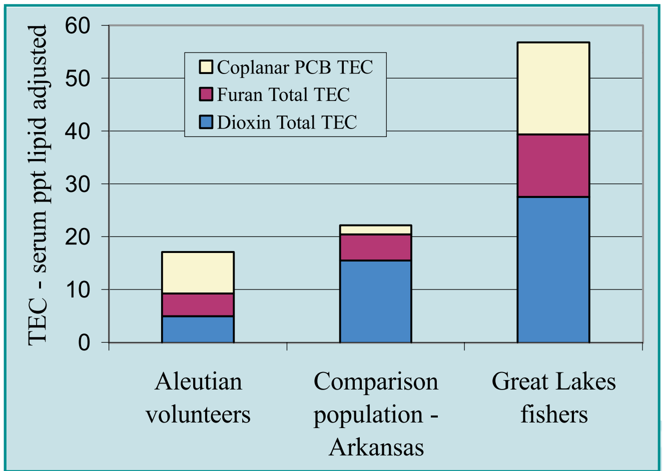



*Figure 5-18. Serum dioxin toxicity equivalence (TEC) concentrations in Aleutian volunteers (n=48) compared with Arkansas (n=70) and Great Lakes fisher (n=31) comparison groups (Middaugh et al., 2000a).*

communities (Middaugh et al., 2000a,b). These communities had become concerned because some Alaskan Steller sea lion blubber had been reported to contain relatively high levels of PCBs (23 ppm, Varanasi et al., 1993; 12 ppm in males, Lee et al., 1996) potentially impacting their use of sea lions as a source of meat and oil. Middaugh et al. (2000a) found that older people had bioaccumulated POPs in their bodies after a lifetime of consumption, whereas young people had relatively low levels. As evident from Figure 5-18, total PCB, dioxin, and furan toxicity equivalence concentrations (TEC) levels in the Aleutian volunteers were similar to those in the background U.S. population (Arkansas) and considerably below fisher exposures on the Great Lakes (Anderson et al., 1998). Middaugh et al. (2000a) also analyzed the age relationship to exposure levels (Figure 5-20) demonstrating increased POPs levels with age. Similar age-related findings are evident in other studies from lower-48 populations and cannot necessarily be ascribed to dietary pattern changes. Because the Aleutian sample sizes were very low and from volunteer populations in isolated, select communities, few conclusions can be drawn, and a broader surveillance is needed to answer key questions and address community concerns.

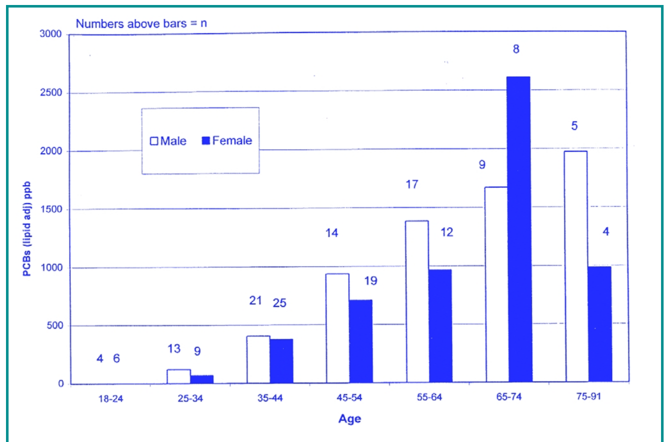



*Figure 5-20. Age distribution of serum PCB levels in Aleutian volunteers (Middaugh et al., 2000a).*

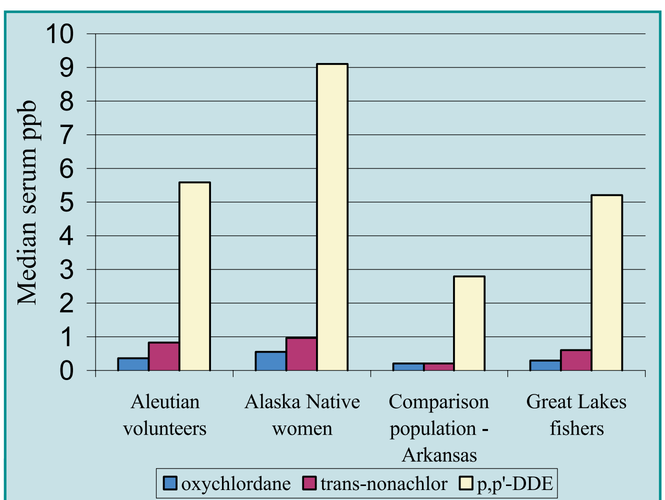



*Figure 5-19. POPs levels in Alaskan v. comparison U.S. populations (Middaugh et al., 2000b). n=166 (Aleuts); 131 (Alaska Native); 180 (Arkansas); 30 (Great Lakes).*

A small group of Aleut women of childbearing age—not pregnant at the time—was identified in the Middaugh et al. (2000a) study. If their levels were to be compared with the maternal plasma study data of the Arctic Monitoring and Assessment Programme (AMAP, 1998), the Aleut women would have the highest levels of pp-DDE (median 0.487 ppm lipid) so far found in the circumpolar region. They were second highest among the other nations for trans-nonachlor (median .035 ppm lipid) and third highest for oxychlordane (median .024 ppm lipid) (Middaugh et al., 2000b). These results strongly suggest that the original pollution sources are distant and international, and the relative elevations of DDT and chlordane derivatives are consistent with the location of the

Aleutians near continuing use regions for these POPs in Asia.

From the other side of Alaska, Arctic Slope mothers have POPs levels (DDT, DDE, mirex, trans-nonachlor, oxychlordane, and PCBs) that are lower than those in the Aleutian/Pribilof Islands women of childbearing age (Simonetti et al., 2001). These levels are comparable with levels in the lower 48 States for background populations (Anderson et al., 1998).

At this time, the trend of virtually all POPs movement to the north is unknown. There has not been an ongoing national surveillance program in place to clearly indicate whether the 12 POPs under the Stockholm Convention are going up, leveling, or going down. There is an indication that in other Arctic nations some forms of PCBs are declining, whereas no trends are apparent for the more chlorinated forms (Hung et al., 2001).

## Ongoing POPs Research in Alaska

Human health and ecological research on POPs levels and effects in Alaska is increasing, linking the domestic and transpolar efforts of the Arctic Monitoring and Assessment Program (AMAP), Arctic Council, U.S. Federal agencies, Alaska State government, and tribal groups. These research efforts cover a spectrum from expanding work on environmental levels through measurements of body burdens and effects along the food chain to wildlife and humans. Emphasis is placed on community involvement in the planning, decision making, and communication of this work. Among these research efforts, measurements are underway of POPs levels transported in the air to Alaska and of levels in water and sediments of the Yukon River. Studies have been conducted on POPs levels in a wide range of species including chinook and chum salmon, Stellers eiders, black-capped chickadees, red-throated loons, and wood frogs. This research is accompanied by expansion of data collection on marine mammals and other high-trophic predators, notably bald eagles and polar bears. With Alaska Natives, traditional food practices are being documented and analyzed to assess not only the contaminant loads but also the nutritional benefits of the diet. POPs levels in mothers and the umbilical cord blood of their offspring are being measured to assess the body burden of contaminants. These data serve as an essential link in studies of potential effects (e.g., developmental, immunological) on the children. Research data have also been published as part of ongoing studies assessing the link between POPs levels and breast cancer (Rubin et al., 1997) and on the effect of HCB and DDE in human cell cultures (Simonetti et al., 2001).

These research efforts in Alaska parallel the POPs reduction and elimination activities under the Stockholm Convention. While the current Alaskan data outlined in this chapter serve to inform U.S. consideration of the Stockholm Convention, the ongoing work will further help to:

- Monitor increases or declines in POPs levels in Alaska
- Detect any wildlife or human hotspots of POPs contamination
- Identify potential domestic and international sources of ongoing POPs contamination
- Guide communities on the risks and benefits of traditional practices
- Increase the general scientific knowledge of the effects of these toxins and the levels at which these effects occur

## Conclusion

POPs can now be measured in all environmental media and species in Alaska. POPs levels in Alaska are generally low, however, when compared to the lower 48 United States. Accompanying these comparatively low levels are isolated examples of elevations that portend a cautionary warning in the absence of international action. DDT/DDE and PCB levels in transient Alaskan killer whales are as high as those found in highly contaminated east coast dolphins, reaching to the hundreds of parts per million in lipid. On Kiska Island in the Aleutians, DDE in bald eagle eggs approaches effect levels seen in the Great Lakes. And Aleuts have some of the highest average DDE and chlordane levels measured in Arctic human populations, highlighting their proximity to continuing emission sources in Asia. Indeed, Alaska's location—geopolitically and climatically—suggests that POPs pollution could be exacerbated in future years in the absence of international controls.

The hunting and dietary practices essential to survival in the Arctic make indigenous humans and wildlife especially vulnerable to POPs. Where animal fat is the currency of life, this intensifies the unique combination of POPs properties to migrate north, associate with fat, persist, bioaccumulate, and biomagnify. For Alaska Natives, current POPs levels vary with location and diet. In the human populations measured (Aleutian, Pribilof, North Slope), POPs levels are similar to those experienced by the background U.S. population, and generally below those of fisher communities around the Great Lakes. It is, therefore, important to emphasize that there are no known POPs levels at this time in Alaska that should cause anyone to stop consuming locally obtained, traditional foods or to stop breastfeeding their children. Current information indicates that the risks associated with a subsistence diet in Alaska are low, whereas in contrast the benefits of this diet and breastfeeding children are well documented (Ebbesson et al., 1996; Jensen and Nobmann, 1994; Nobmann et al., 1992; Scott and Heller, 1968; Singleton, in press). Further investigation and assessment are needed for specific species and foods in traditional diets, and to broaden the database across Alaskan communities. The international AMAP (1998) report came to the same conclusion for the entire Arctic, and Alaskan levels of most of the POPs are generally lower than for other polar nations. The international community has also moved to further reduce POPs contamination through negotiation of the Stockholm Convention on POPs, implementation of which should help minimize future increases in levels of the listed POPs.

> *We are as one with our ancestors and children.*
>
> *We are as one with the land and animals. [Alaska Native anthropologist Rosita Worl]*

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